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B-LPS AND MARKSMANSHIP AS TESTED ON THE WEAPONEER

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and B.E. Stuck

DIVISION OF OCULAR HAZARDS RESEARCH

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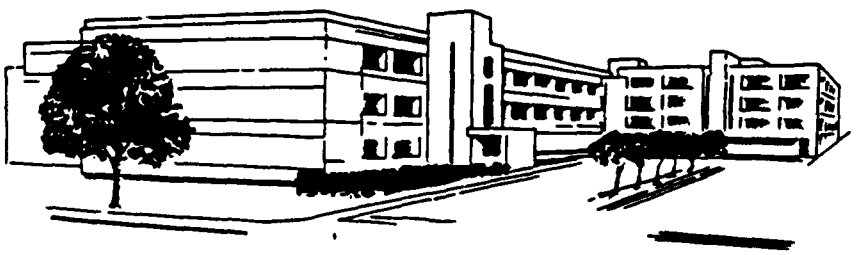

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BLPS and Marksmanship as Tested on the Weaponeer, W.B. Bennett, J.W. Molchany, G.R. Mastrolanni and B.E. Stuck. Lab. Note No. 90-80

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Marksmanship performance was evaluated using the Weaponeer trainer under six conditions. These conditions were control, Ballistic spectacles, B-LPS with 2 wavelength frontsert, Ballistic sunglasses and a prototype multiwavelength filter. The purpose of this experiment was to determine if any of these protective glasses would have a detrimental effect on marksmanship. Eleven volunteers fired a total of 180 rounds, thirty rounds per condition, on the Weaponeer over a two day periods. Three targets (100m, 250m high contrast and 250m low contrast) were presented in a random order. The percentage of hits per target for each condition was calculated. The Analysis of Variance of these data showed significant main effects for target and filter conditions, with the prototype filter producing the largest decease in performance. Therefore, the use of some of these filters could jeopardize the success of a combat mission. However the data suggests that practice and training can increase performance and possibly eliminate the effect.

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ABSTRACT

Marksmanship performance was evaluated using the Weaponeer trainer under six conditions. These conditions were control, Ballistic spectacles, B-LPS with 2 wavelength frontsert, Ballistic sunglasses and a tri-stimulus multiwavelength filter. The purpose of this experiment was to determine if any of these protective glasses would have a detrimental effect on marksmanship. Eleven volunteers fired a total of 180 rounds, thirty rounds per condition, on the Weaponeer over a two day period. Three targets (100m, 250m high contrast and 250m low contrast) were presented in a randomized order. The percentage of hits per target for each condition was calculated. The Analysis of Variance of these data showed significant main effects for target and filter conditions, with the Prime filter producing the largest decrease in performance. Therefore, the use of some of these filters could jeopardize the success of a combat mission. However, the data suggest that practice and training can increase performance and possibly eliminate the effect.

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B-LPS and Marksmanship as Tested on the Weaponeer.
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Marksmanship training is an integral part of every soldier's training. Soldiers are first exposed to marksmanship training in Basic training where they are required to 'qualify' with the M-16 before graduation. Furthermore, most soldiers are required to 'requalify' every year at a rifle range. This is to ensure the readiness of our combat troops. The Weaponeer (Spartanics Ltd. Rolling Meadows, Illinois) was developed to decrease the cost associated with training soldiers (transportation, ammunition, etc). Weaponeer applications go beyond use as a training tool, as Schendel et al. found that it could also be used to predict record fire performance as long as marksmanship training was not provided immediately preceding Weaponeer testing (1).

With the increased use of lasers in modern weapon systems, the possibility of exposure to a laser has correspondingly increased. The Army has developed an ocular laser protective system known as the Ballistic Laser Protective Spectacles (B-LPS). With the widening use of this device, it has become necessary to determine how these protective glasses affect not only daily tasks, but also how they would affect performance in combat. The purpose of this experiment was to determine how protective eyewear affects marksmanship of soldiers.

METHODS

Volunteers. Eleven male volunteers ranging in age from 22 to 35 years, from the Letterman Army Institute of Research, Presidio of San Francisco, CA served as participants. Only volunteers with 20/20 visual acuity, corrected or uncorrected, were accepted for this study. Each volunteer was given a Volunteer Agreement/Privacy Act Statement to read and sign.

Apparatus. The apparatus used for this experiment was a modified Weaponeer marksmanship trainer. The Weaponeer has been fully described elsewhere (1). For this experiment the Weaponeer was augmented with a computer. The controlling software presented the 100m target for 2 seconds and the 250m high and low contrast targets for 4 seconds. The Weaponeer consists of a

modified M-16A1 rifle and infrared sighting system providing an accurate record of shots. Also, the Weaponeer is equipped with adjustable sound levels and recoil on the rifle to simulate live fire.

Procedure. After a brief question and answer period, each volunteer was asked to participate in the study. To begin each firing session, the volunteer was given the opportunity to adjust the sand bags and assume a comfortable standing firing position. After the volunteer indicated that he was ready, he was required to zero the weapon by firing a three round shot group at the zero target (25m). Examining the shot group revealed if any adjustments to the sights were necessary. Testing proceeded once the volunteer was satisfied with his 'zero'. During testing, the 'kill' button on the Weaponeer was activated. The target dropped if hit, thus giving the volunteer an assessment of his performance. Sometimes it was difficult for the volunteer to determine if he actually 'hit' the target or if the target fell because the allotted time had passed. Therefore, if the volunteer had any questions about his performance, the monitor provided the answer.

Training. The volunteers received 1 day of training comprising 45 targets. The targets were presented in a random order so that each of the three targets appeared 5 times out of every 15 target presentations, for a total of 15 engagements per target. There was a total of 5 randomized target sequences, so none of the volunteers fired at the same order of targets more than once.

Test Day. All volunteers were tested over 2 days. Each test day consisted of 2 sessions of 45 targets. The volunteer was given the opportunity to rest between the 2 sessions. The training day and test days were scheduled for 3 consecutive days at approximately the same time each day. Engagement time for the 100m target was 2 sec, while the 250m targets were presented for 4 sec.

Filters. A total of six different filter conditions were used. Each test day was divided into 2 sessions which consisted of three 15 target groups. The first group of 15 targets served as the control

condition with no filters used. The remaining 5 filter conditions were: the clear Ballistic Laser Protective Spectacle (B-LPS), sunglasses, the B-LPS with green frontsert (2 wavelength protection), the B-LPS with brown frontsert (3 wavelength protection), and a tristimulus multiwavelength filter which blocked all but 3 narrow wavelength bands. The Prime filter is not part of the Army's B-LPS system and was used for comparison purposes. The filters were assigned at random in an exhaustive sequence with a different sequence used on each of the test days. Between filters, the volunteer stopped firing to change glasses. He was given time to assume a comfortable firing position before testing continued, signaling when he was ready.

Test Scores, Statistical Analysis & Design. The computer recorded the target number, target type, if a shot was fired, time of the shot, and result (hit, miss, or late) which was entered by the operator. The total number of shots fired within the time limit and the percentage of hits per target for each filter condition was calculated from this data. The percentage of hits per target for each filter was used in the Analysis of Variance (ANOVA). This study was designed as a 3 (target) x 6 (filters) factorial design with repeated measures. The ANOVAs were performed with BMDP Statistical Software program 2V (2). In all cases, a $p < 0.05$ was considered statistically significant. The Least Significant Difference (LSD) test was used for the post hoc comparisons (3).

RESULTS

The 2-way ANOVA (filter x target) found a significant effect both for filter condition (Mean Square (MS) = 0.28, df=5; MS Error= 0.04, F= 7.27, p< 0.0001) and target (MS= 0.81, df=2; MS Error= 0.04, F= 22.00, p< 0.0001). Separate ANOVAs were performed for each target. These results are shown in Table 1. The LSD test for the 100m high contrast target showed the Prime filter significantly differed from the control, clear B-LPS, green frontsert, and sunglasses. Also, the brown frontsert was significantly different for the same conditions except the green frontsert. The 250m low contrast again showed that the Prime filter significantly differed from all other filters. However, the brown frontsert was not significantly

FIGURE 1. B-LPS and WEAPONEER PERFORMANCE ALL TARGETS

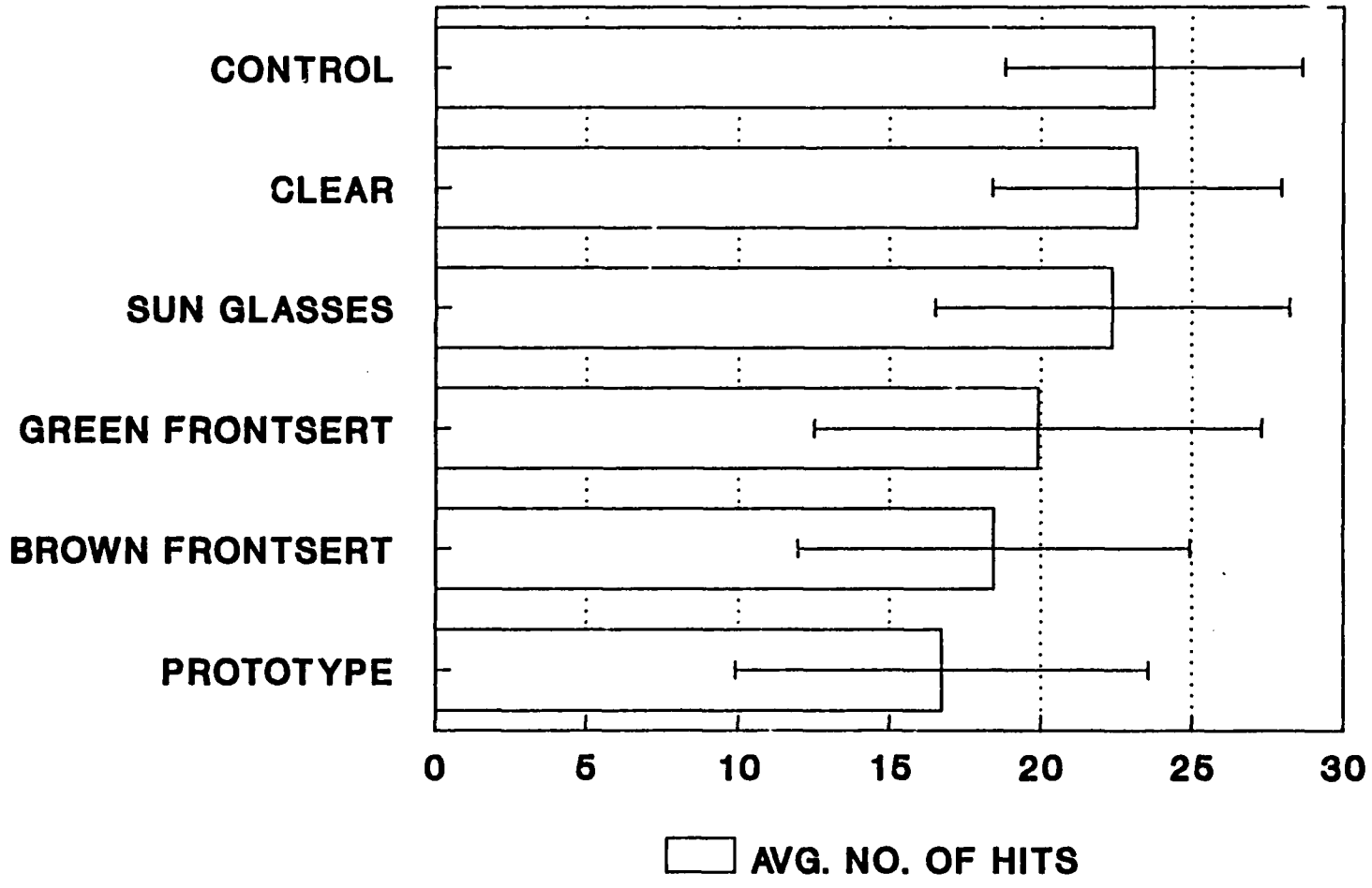


FIGURE 2. B-LPS and WEAPONEER PERFORMANCE TARGET 1 - 100m

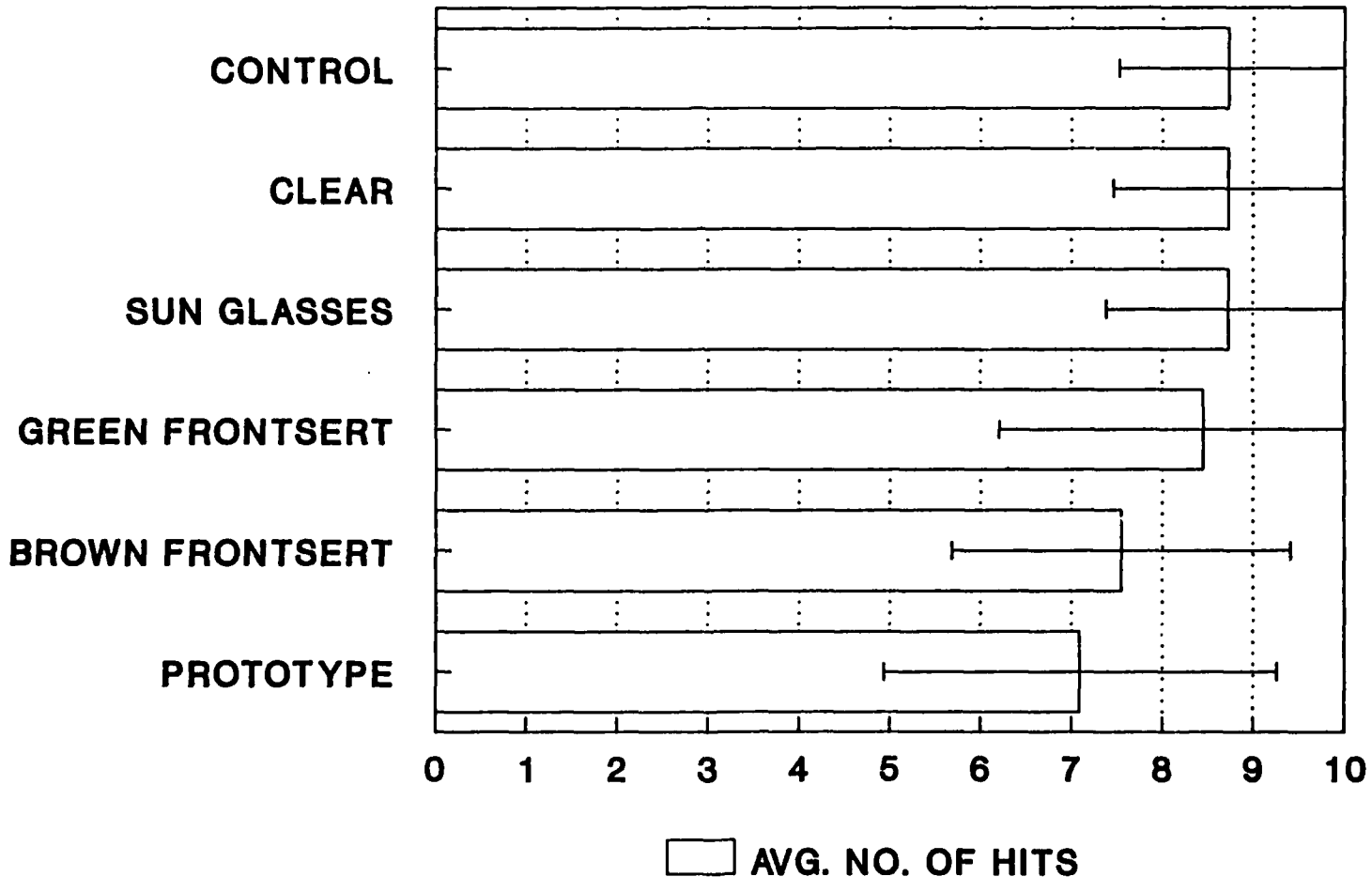


FIGURE 3. B-LPS and WEAPONEER PERFORMANCE TARGET 2 - 250m LOW CONTRAST

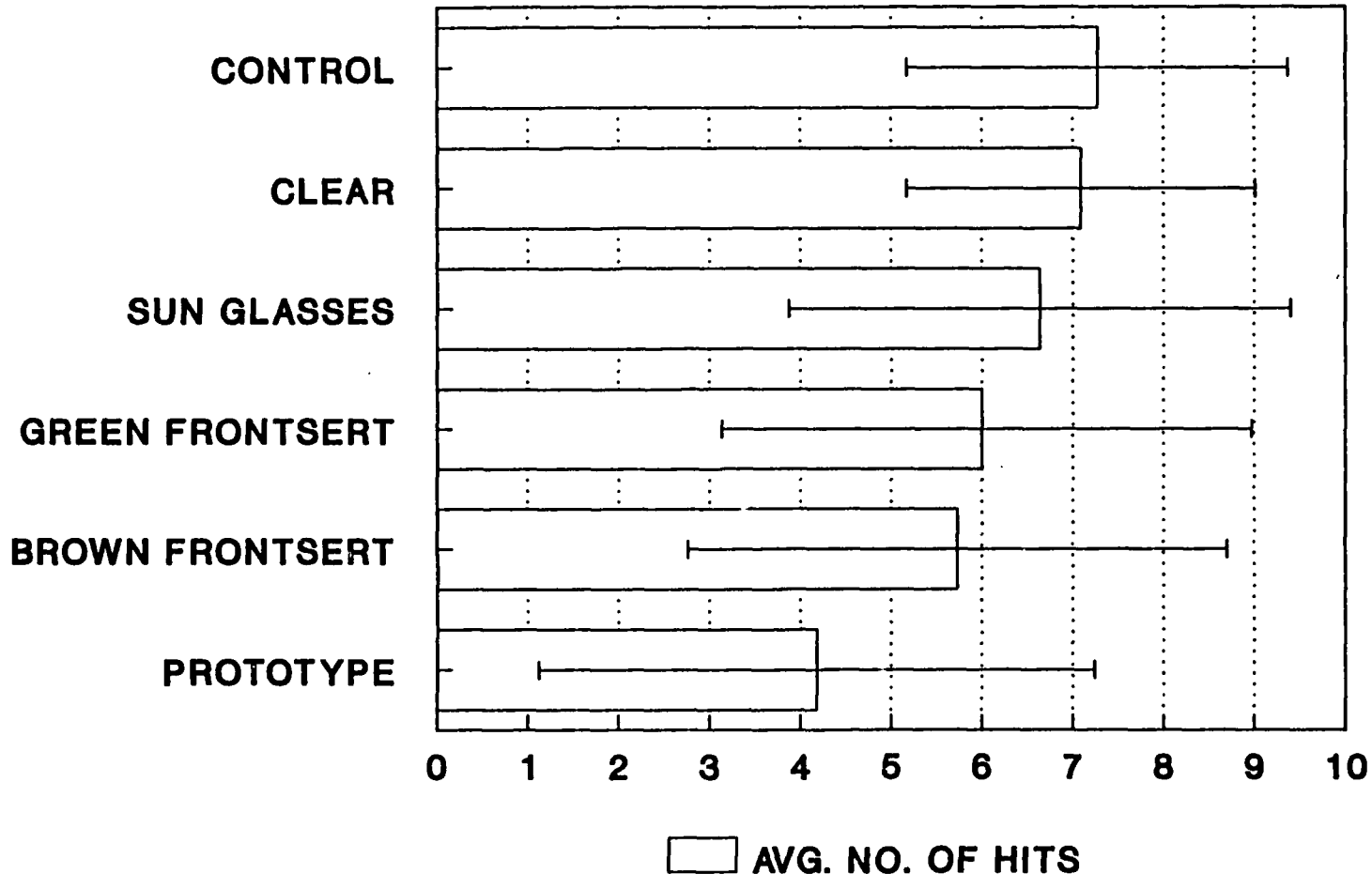
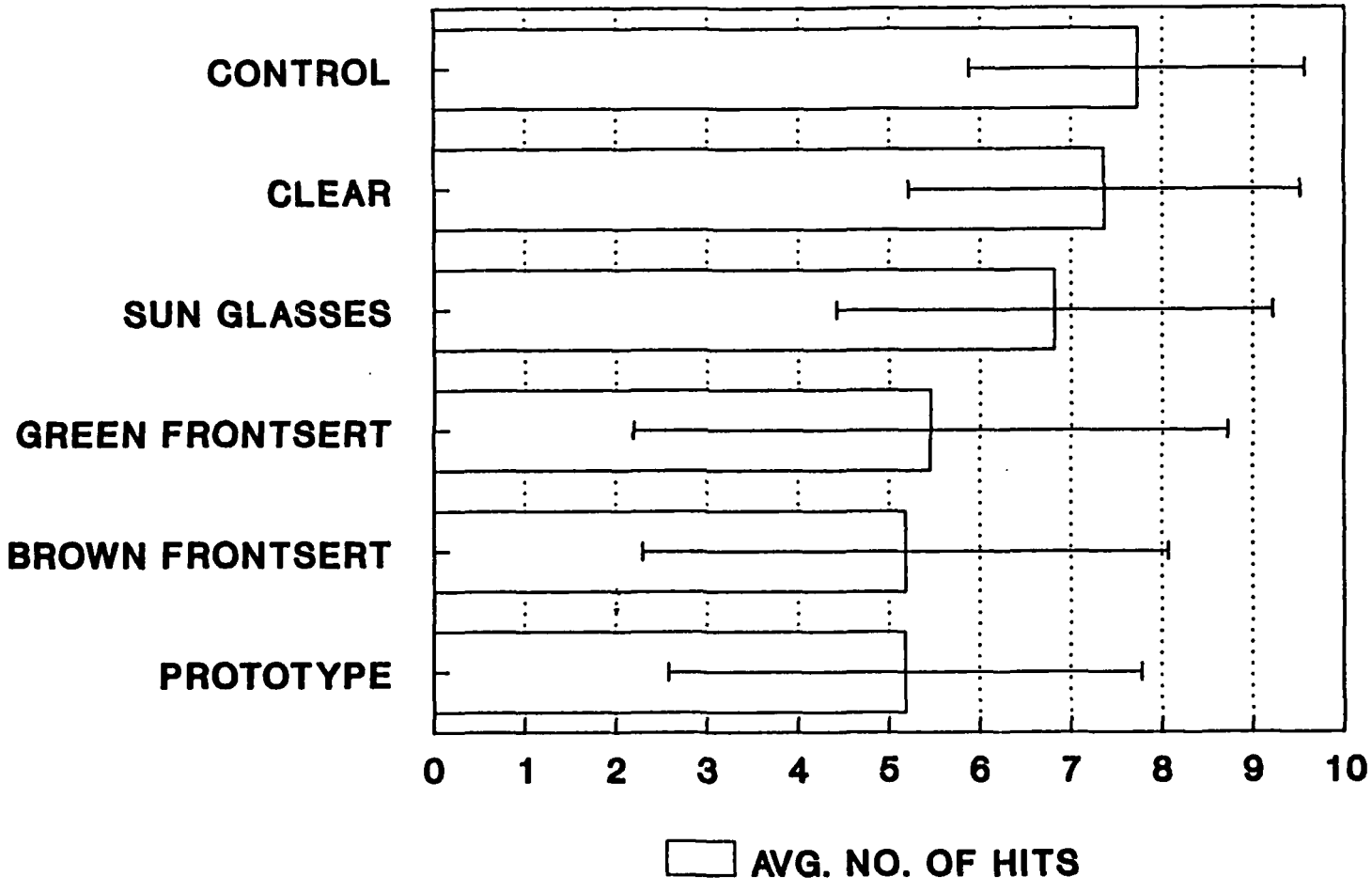


FIGURE 4. B-LPS and WEAPONEER PERFORMANCE TARGET 3 - 250m HIGH CONTRAST



different from any of the conditions. For the 250m high contrast the Prime filter, brown frontsert and green frontsert all showed a significant difference from the control, clear B-LPS, and sunglasses. The summary of the post hoc tests are listed in Appendix 1. A summary of individual performance is presented in Appendix 2.

TABLE 1

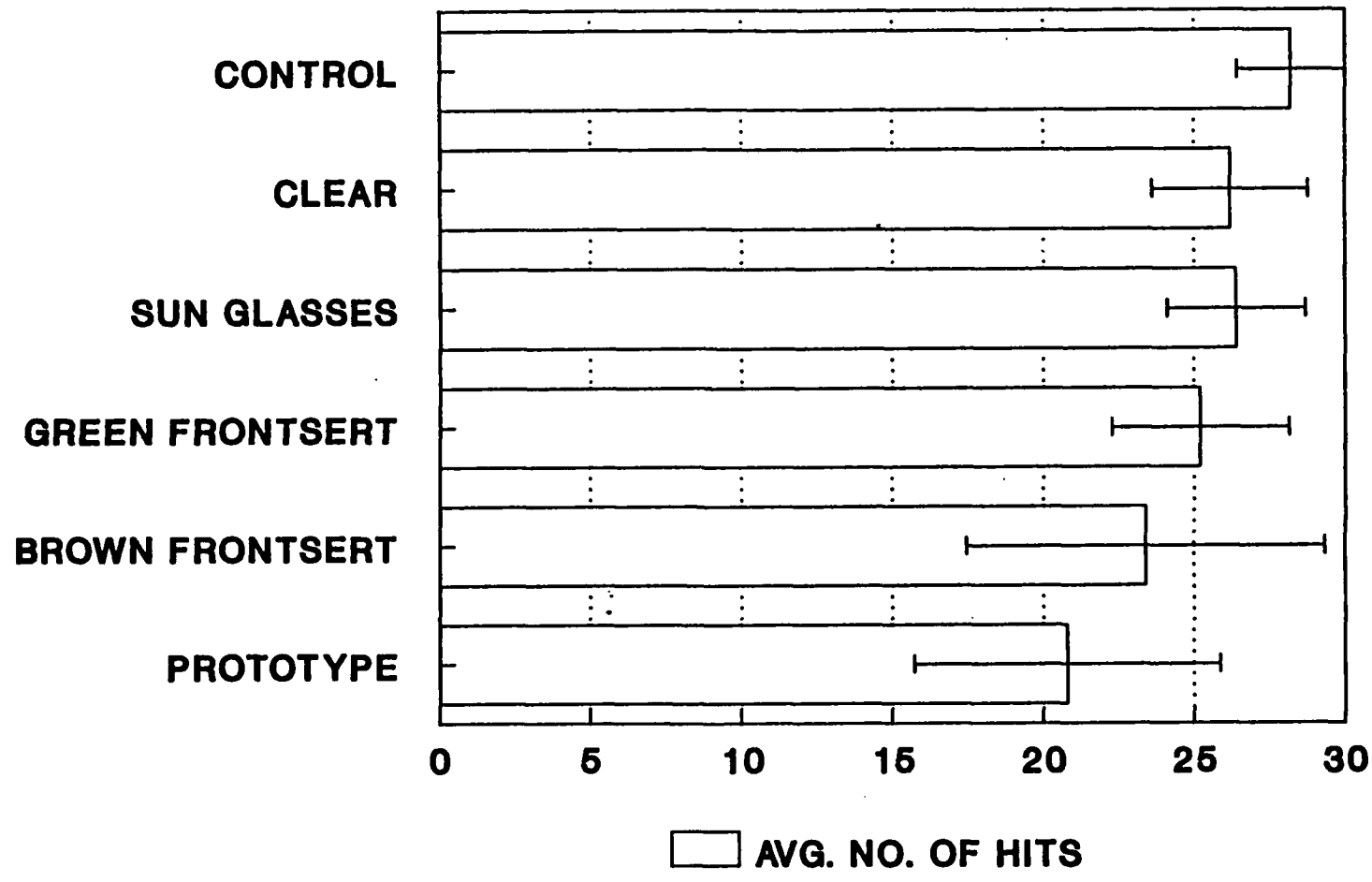
ANOVA Summary Table for Individual Targets

	MS	df	MS Error	F	p
100m high contrast	0.05	5	0.02	3.01	<0.02
250m low contrast	0.14	5	0.04	3.96	<0.01
250 low contrast	0.15	5	0.03	5.76	<0.001

Figure 1 shows the mean number of hits for all targets across the 6 conditions. There is very little variation among the control, clear and sunglass conditions. The green frontsert shows a 5% decrease in the average number of hits. The number of hits decreases another 2% for both the brown frontsert and Prime filter. Figure 2 depicts performance for the 100m target. The control, clear, sunglass, and green frontsert show approximately equal performance. However, mean performance for the brown frontsert and Prime filter represent a 15-20% decrease from the first 4 conditions. The 250m low contrast target (Figure 3) shows a steady decline in performance from the control and clear B-LPS conditions. The sunglass shows an 8% decrease, followed by decreases of 16% for the green frontsert, 20% for the brown frontsert, and 40% for the Prime filter. The 250m high contrast target (Figure 4) shows a 28% decrease from the control for the green frontsert and 33% for both the brown frontsert and the Prime filter.

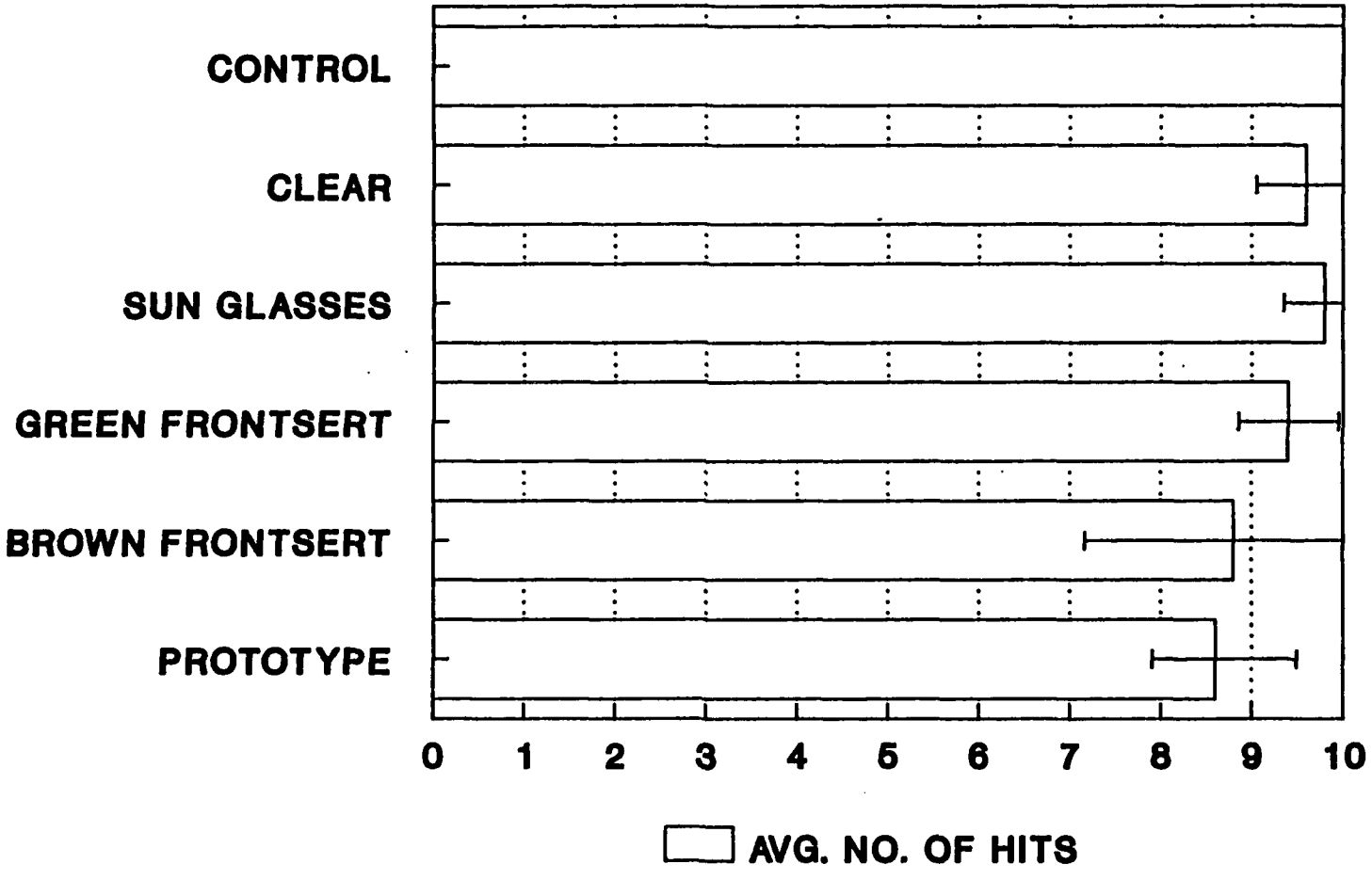
A second series of ANOVAs examined experienced Weaponeer users vs non-experienced users. Group 1 users had previous experience, either through training for weapons requalification or participating in earlier

FIGURE 5. B-LPS and WEAPONEER PERFORMANCE ALL TARGETS



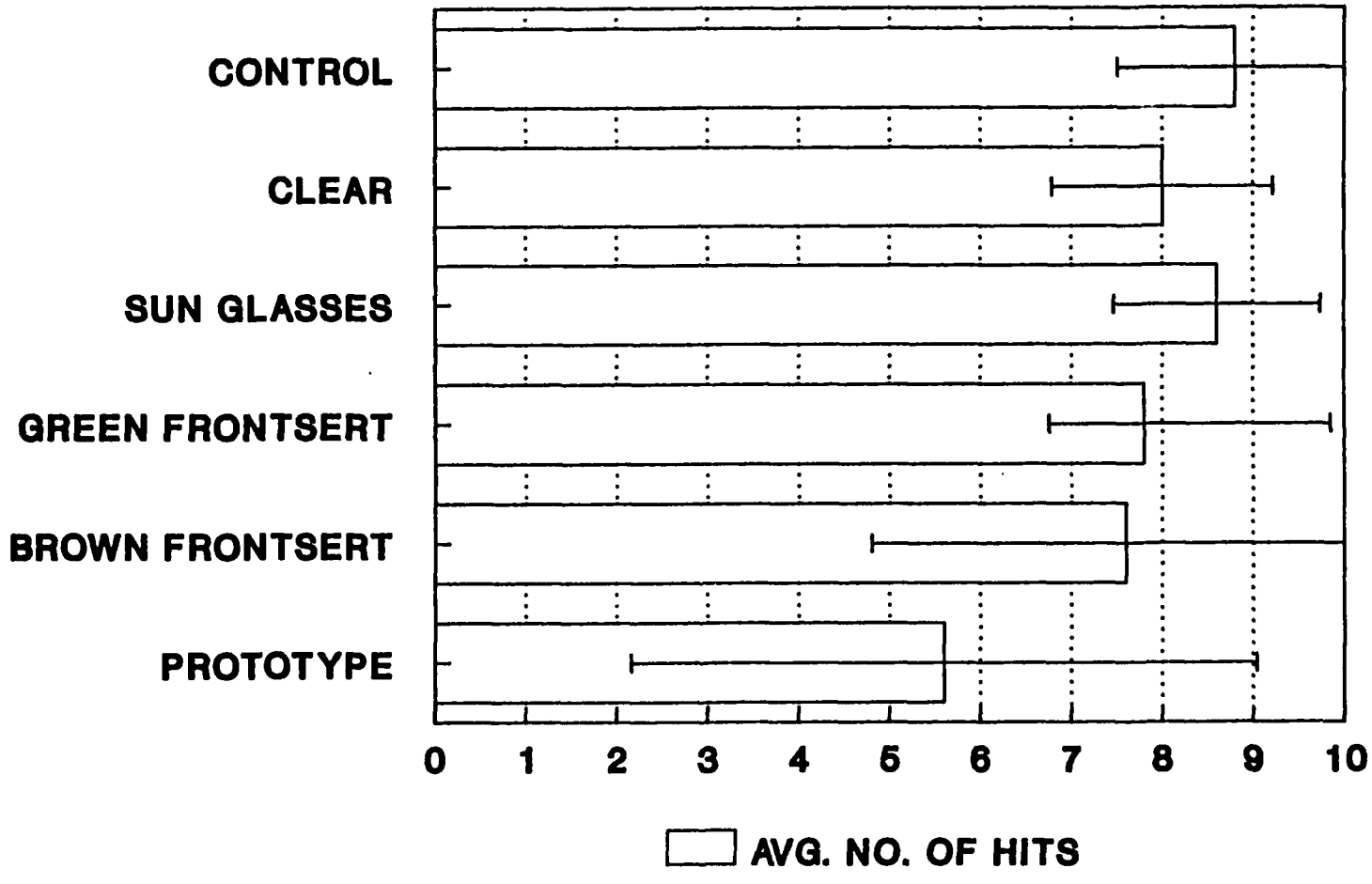
GROUP 1

FIGURE 6. B-LPS and WEAPONEER PERFORMANCE TARGET 1 - 100m



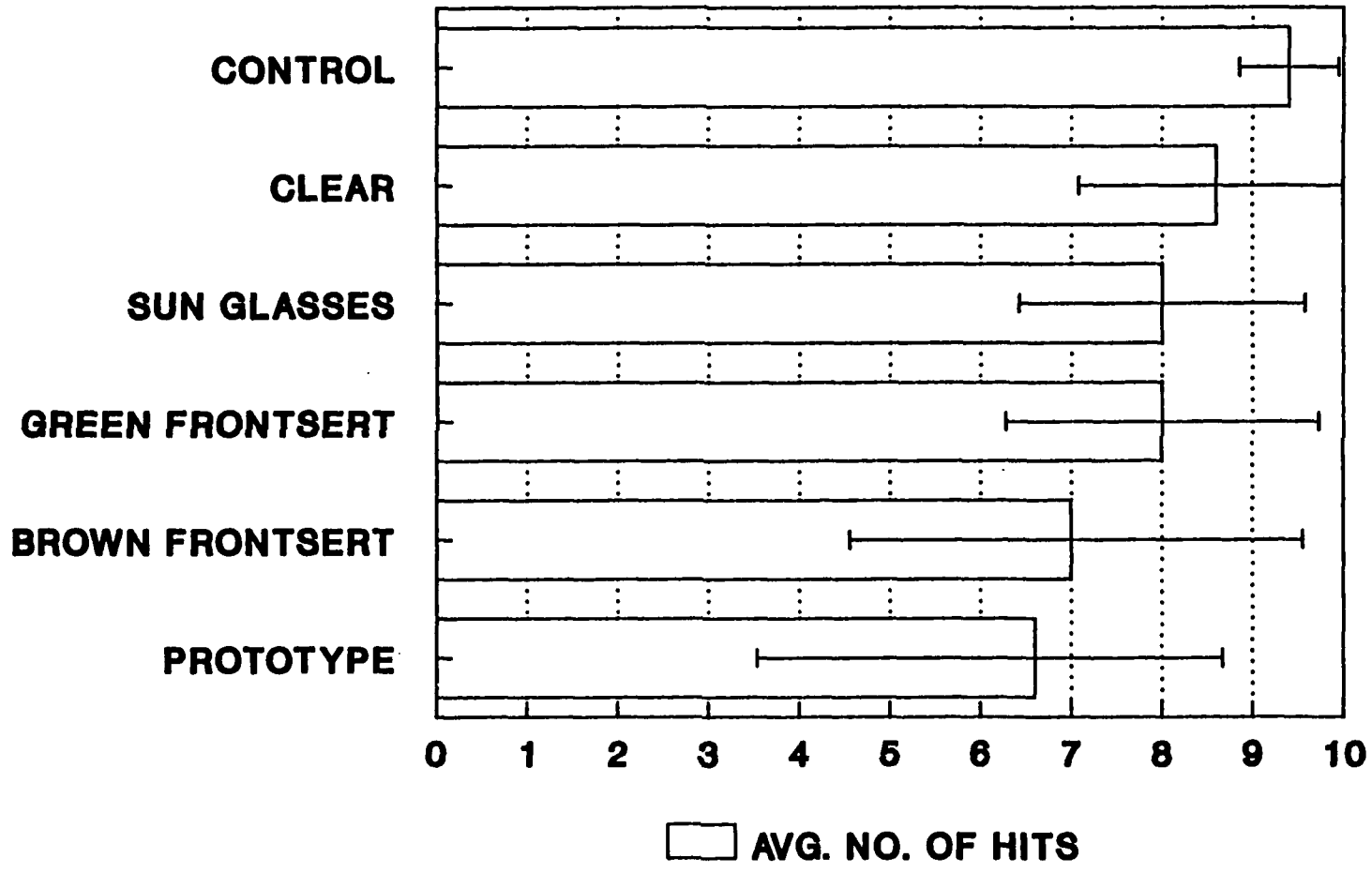
GROUP 1

FIGURE 7. B-LPS and WEAPONEER PERFORMANCE TARGET 2 - 250M LOW CONTRAST



GROUP 1

FIGURE 8. B-LPS and WEAPONEER PERFORMANCE TARGET 3 - 250m HIGH CONTRAST



GROUP 1

Weaponeer studies. Group 2 had no previous experience with the Weaponeer. These results are presented in Table 2.

The results of the LSD test for Group 1 (Appendix 3) for the 100m high contrast target showed that both the Prime filter and brown frontsert differed significantly from the control, clear B-LPS, and sunglasses. For the 250m low contrast target, the Prime filter was significantly different from the control and sunglasses. The Prime filter and brown frontsert showed significant differences from the clear B-LPS and control for the 250m high contrast target.

Figure 5 (all targets combined) shows no significant difference for the first 4 conditions. There was a slight decrease in the average number of hits for the brown frontsert, however, the variability among the volunteers increased. The Prime filter shows a 25% decrease from the control condition. (Note the decreased variability compared to the brown frontsert.)

The 100m target represented by Figure 6 depicts the same relationship, with the exception of a smaller decrement in performance for the Prime filter. Figure 7 depicts performance for the 250m low contrast target. Performance was matched across the first 4 filters with little change in the variability. The brown frontsert caused a >10% performance decrement and a large increase in variability. The Prime filter produced a 20-30% decrease in performance with very large variability. Figure 8 shows a 10% decrease with the sunglasses and green frontsert compared to the control for the 250m high contrast target. Performance decreased another 10% for the brown frontsert and Prime filter.

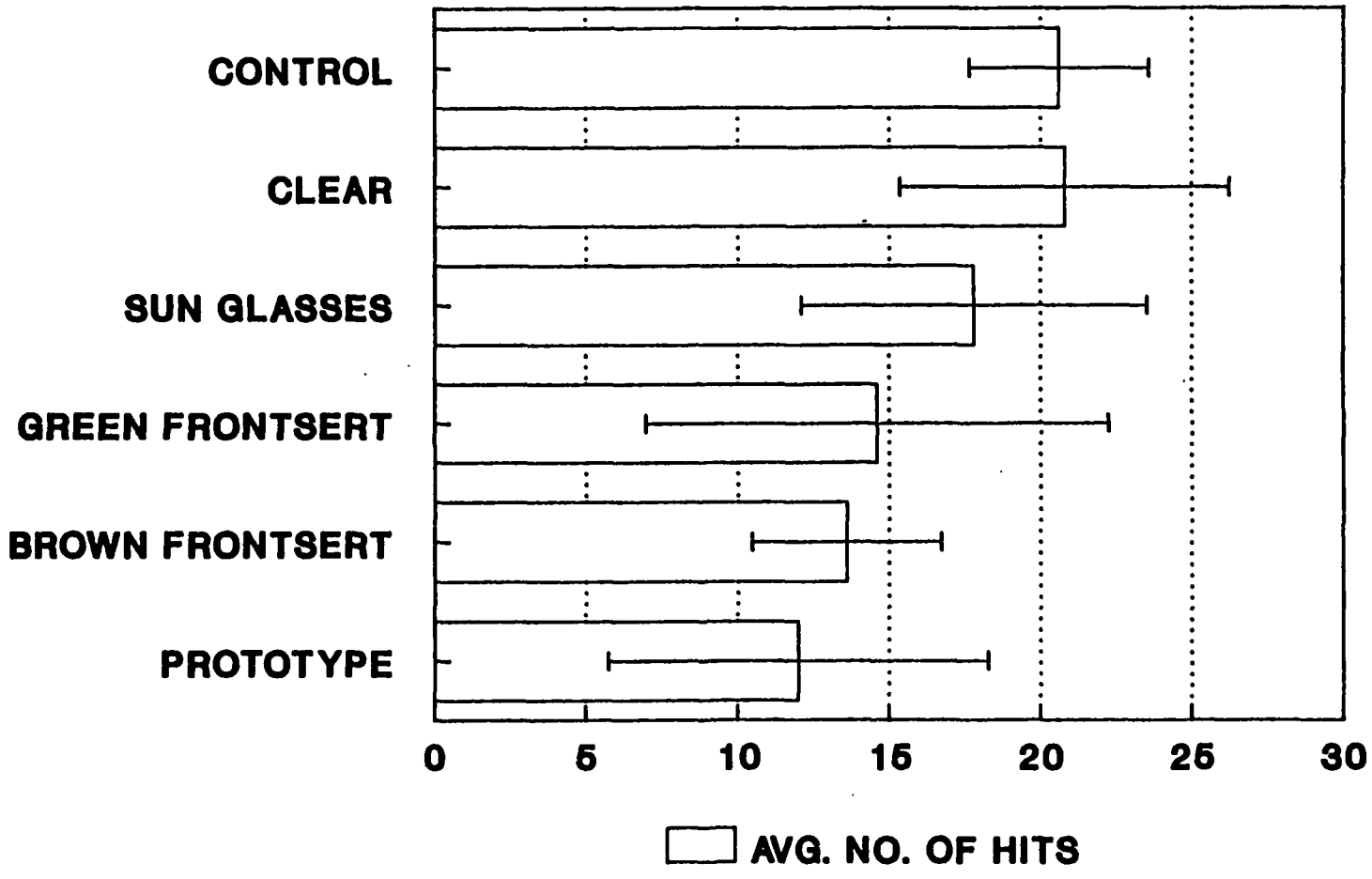
The LSD test for Group 2 (Appendix 4) for the 100m high contrast target shows the Prime filter to be significantly different from the sunglass, clear B-LPS and control. The 250m low contrast target results showed that the Prime filter and brown frontsert differed significantly from the clear B-LPS and control condition. For the 250m high contrast target, the control and clear B-LPS were significantly different from both frontserts.

TABLE 2

ANOVA Summary Table
of Experienced vs Non-Experienced Users

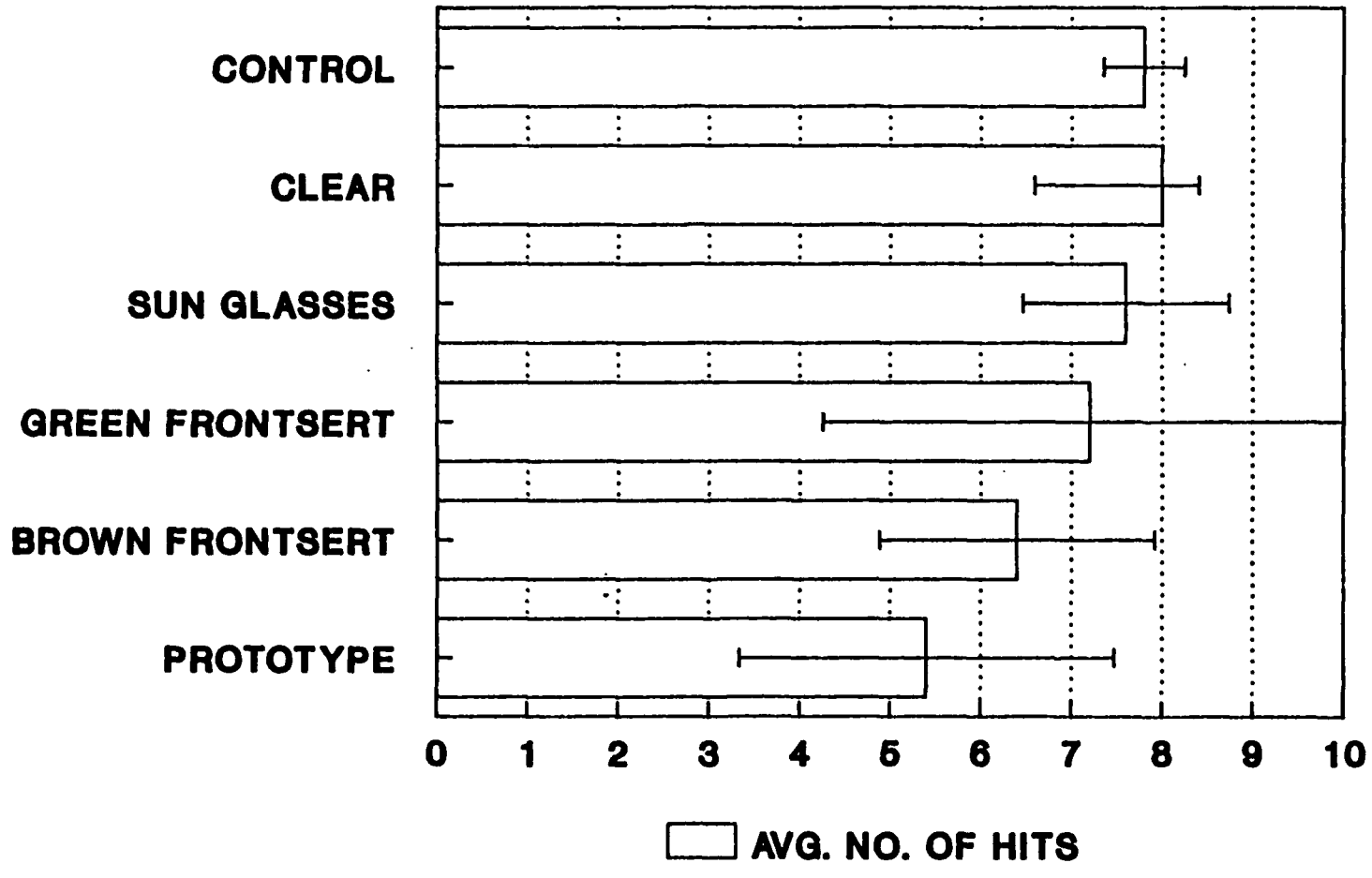
Condition	MS	df	MS Error	F	p
Group 1					
Filter	0.11	5	0.054	4.58	0.004
Target	0.24	2	0.041	5.82	0.03
F x T	0.01	10	0.015	0.68	0.57
Group 2					
Filter	0.23	5	0.054	4.25	0.07
Target	0.55	2	0.055	9.97	0.008
F x T	0.023	10	0.023	0.96	0.45
Group 1					
100m high contrast	0.016	5	0.005	3.09	0.03
250m low contrast	0.065	5	0.036	1.81	0.15
250m high contrast	0.053	5	0.014	3.88	0.01
Group 2					
100m high contrast	0.049	5	0.021	2.33	0.08
250m low contrast	0.116	5	0.039	3.00	0.03
250m high contrast	0.108	5	0.041	2.66	0.05

FIGURE 9. B-LPS and WEAPONEER PERFORMANCE ALL TARGETS



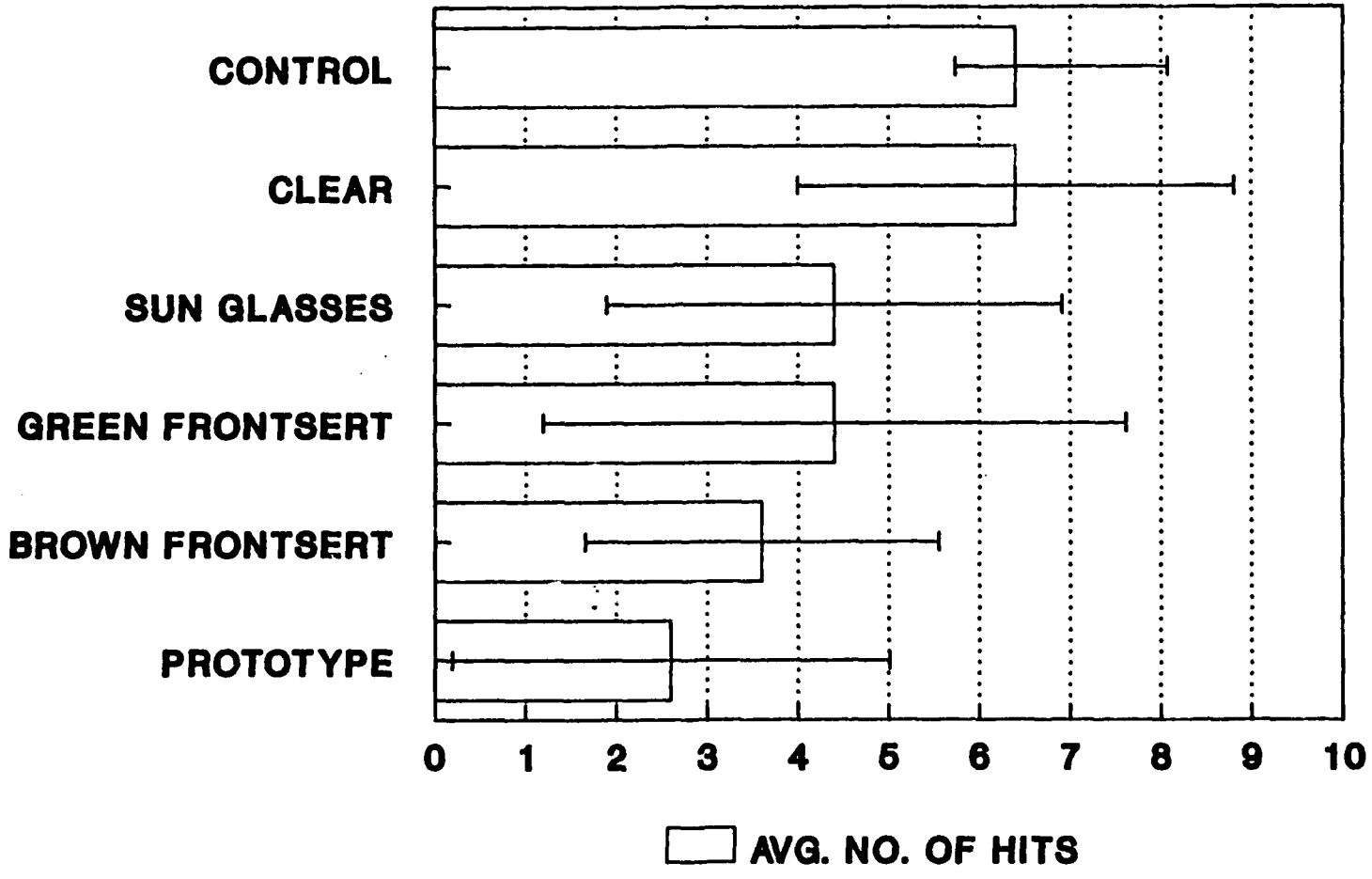
GROUP 2

FIGURE 10. B-LPS and WEAPONEER PERFORMANCE TARGET 1 - 100m



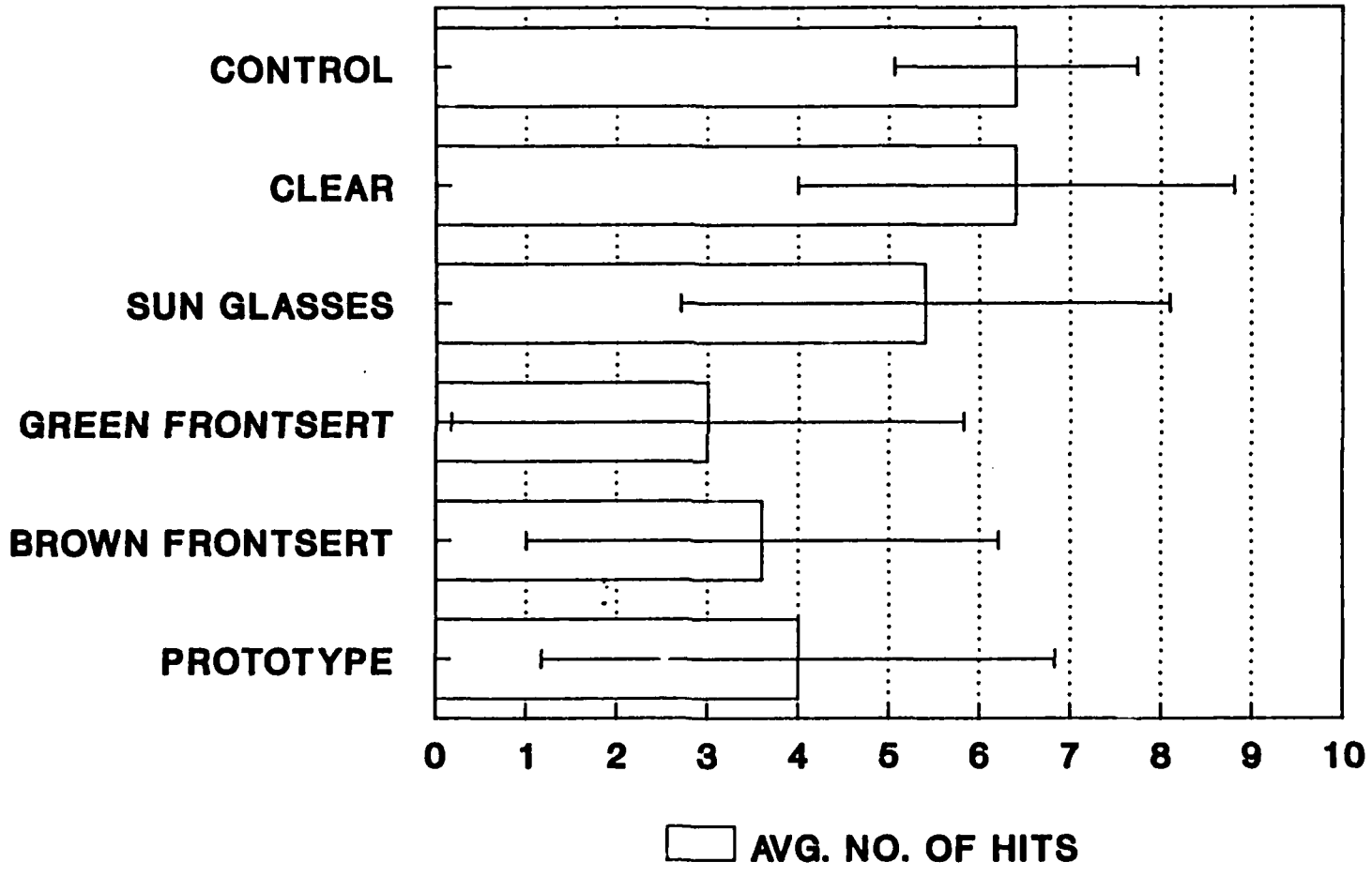
GROUP 2

FIGURE 11. B-LPS and WEAPONEER PERFORMANCE TARGET 2 - 250m LOW CONTRAST



GROUP 2

FIGURE 12. B-LPS and WEAPONEER PERFORMANCE TARGET 3 - 250m HIGH CONTRAST



GROUP 2

Figure 9 (all targets combined) shows equal performance for the control and clear B-LPS and a slight decrease in performance associated with the sunglasses. Performance decreased 25-35% for both frontserts and the Prime filter. Figure 10 (the 100m high contrast target) shows approximately equal performance for the first 4 conditions with the green frontsert showing the largest variability among the volunteers. There was a slight decrease in performance with the brown frontsert and a 20-25% decrease with the Prime filter. The 250m low contrast target (Figure 11) depicts equal performance for the control and clear B-LPS conditions; a 20% decrease in performance associated with the sunglasses and green frontsert; a slight decrease for the brown frontsert; and a 60% decrease from baseline performance for the Prime filter. The 250m high contrast target (Figure 12) shows matched performance for the control and clear B-LPS, with larger variability for the clear B-LPS. A 10% decrement in performance can be observed for the sunglasses. The 2 frontserts and Prime filter produced the largest performance detriment (25-30%). All filters showed a largely increased variability compared to the control condition.

Figure 13 represents the mean No Fire for all targets. There was no significant difference in the number of No Fires for the first 3 conditions. There was only a slight increase in the average number of No Fires for the green frontsert. However, the number of No Fires approximately doubled for the brown frontsert and was 3 1/2 times greater for the Prime filter. Figure 14 shows that the 100m target had the largest number of No Fires. Figure 14 parallels Figure 13 except that the number of 100m target No Fires with the brown frontsert is approximately 2 1/2 times greater than the first four conditions. For the two 250m targets, the number of No Fires was not significant, but the Prime filter produced the largest number of No Fires. Also, all the experimental conditions except the clear B-LPS caused a slight increase in the number of No Fires for the 250m low contrast target. The number of No fires varied significantly among the volunteers for all conditions and targets with the Vclunteers in Group 2 accounting for most of the No Fires.

FIGURE 13. NUMBER OF NO FIRES ALL TARGETS

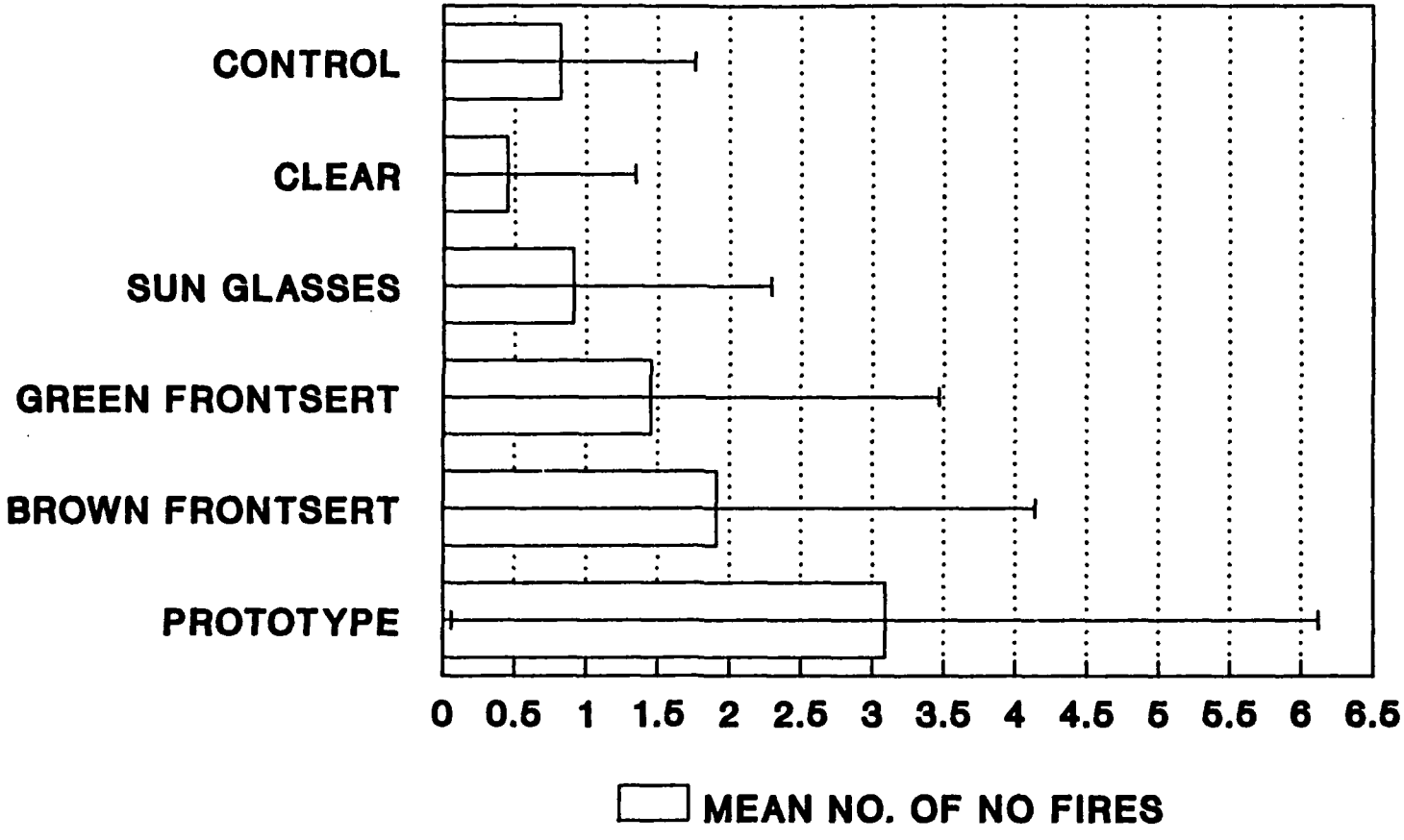


FIGURE 14. NUMBER OF NO FIRES 100m TARGET

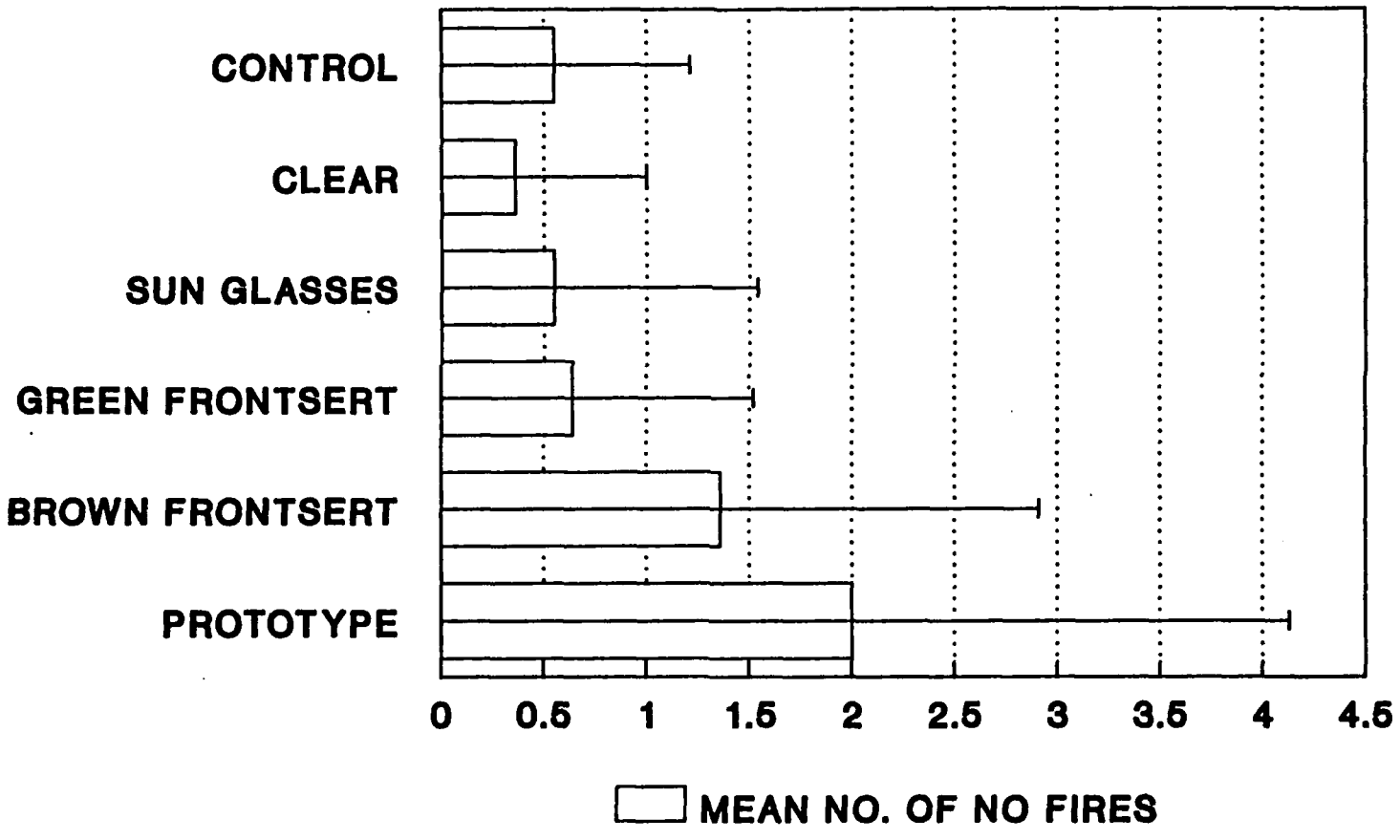


Table 3 shows average performance for all 3 targets compared to the percent transmission of the condition. Overall, performance decreased as transmission decreased except that performance with the green frontsert was slightly lower than that with the sunglasses even though the green frontsert had a slightly higher transmission.

TABLE 3

Percent Transmission vs Performance for all Targets Combined

Condition	T*	Overall	Group 1	Group 2
Control	100%	23.73	28.2	20.6
Clear BLPS	75%	23.18	26.2	20.8
Green Frontsert	45%	19.91	25.2	14.6
Sunglass	23%	22.36	26.4	17.8
Brown Frontsert	10%	18.45	23.4	13.6
Prime Filter	11%	16.73	20.8	12.0

* T= Photometric Luminous Transmittance

Radiometric measurements of the high and low contrast silhouettes and their respective backgrounds were made with an Imagining Spectroradiometer (Optronics Laboratory, Model 740A(740 A-S/740-IC/IBM PC). These data were then processed by the auxiliary program "CHROM", which gave results in photometric units. The resulting luminous flux values of "CHROM" were used to calculate the contrast ratios for the targets. These data are presented in Table 4.

TABLE 4

LUMINANCE* AND CONTRAST RATIOS

		Back-ground	Silhouette	Contrast Ratio
High contrast	no filter	114.60	9.21	0.85
	Clear BLPS	85.14	6.85	0.85
	Green Frontsert	50.77	4.05	0.85
	Sunglass	27.43	2.18	0.85
	Brown Frontsert	15.18	1.17	0.86
	Prime Color	13.79	1.08	0.85
Low contrast	no filter	87.31	39.9	0.37
	Clear BLPS	64.84	29.64	0.37
	Green Frontsert	38.37	18.33	0.35
	Sunglass	20.97	9.34	0.38
	Brown Frontsert	11.70	5.10	0.39
	Prime Color	10.44	4.64	0.38

* - Luminance values for background and silhouette are given in cd/m^2.

DISCUSSION

Several factors that could contribute to decreased marksmanship performance are reduced visibility, decreased engagement time, increased difficulty of targets, and psychological effects as discussed in other studies (4). The targets remained constant throughout the experiment, as did engagement time. No stressors were incorporated into the experiment. Therefore, the probable cause for decreased performance was decreased visibility.

Two strategies for affording laser protection were employed in the filters. The first, used in the B-LPS, attenuates specific, relatively narrow wavelength bands, while preserving the widest possible transmission bands. The second, used in the Prime filter, transmits 3 narrow wavelength bands and attenuates all others. Both strategies decrease the amount of available light to the eye. The brown frontserts and Prime filter had the lowest luminous transmittance (-10%); consequently, they produced the lowest scores. The clear B-LPS had the highest luminous transmittance (80 %) and produced no significant difference from the control. The luminous transmittance for the green frontsert was 45% and the sunglass 23%. Although the sunglass had a lower luminous transmittance than the green frontsert, performance was not as greatly effected. This is due to the difference in spectral transmission between the two. The sunglass reduced all wavelengths, whereas, the green frontsert attenuated 2 specific wavelength bands.

Figures 2-4 illustrate marksmanship performance for the 3 targets. Clearly, performance for the 100m target was best (a larger high contrast target). Better comparisons of performance can be made with the 250m high and low contrast targets. Both targets were presented for 4 sec and their background luminances were 87.31 cd/m^2. (This luminance can be compared to a piece of white paper 1m from a 100W light bulb or a dark overcast day.) The silhouette luminance for the 250m high contrast target was 9.21 cd/m^2 as opposed to 39.9 cd/m^2, with contrast ratios of 81% and 37%, respectively. Performance was plainly higher for the 250m high contrast target for the control, clear B-LPS, and sunglass conditions. Attenuation of the ambient

illumination was relatively flat across the visible spectrum for the 2 filtered conditions above. This is not true of the remaining filter conditions.

Another possible factor contributing to decreased performance was the poor fit of the glasses for all the individuals. In one instance, the fit was poor enough that one volunteer had to tilt the glasses to see through the center of the lens when trying to fire the weapon; otherwise, his view was through the nasal lens edge or between the two lenses. No effort was made to correct the fit of the glasses, but instead the volunteer was allowed to fire with the B-LPS tilted at an angle. This volunteer's performance was affected by all of the filter conditions. Wearing no glasses on the practice day, he only missed 2 shots out of 45, but with the glasses he missed 55 out of 150 targets. However, the fit of the glasses could not be the dominant factor affecting performance, since most of the volunteers showed no significant difference between the control and clear B-LPS.

Individual variability was the hallmark feature in this study. Three volunteers, including the top two shooters, performed equally well with any of the protective materials. Two volunteers were only affected by the Prime filter. Both had trouble with the 250m low contrast target and one also had difficulty with the 250m high contrast target. This volunteer missed 50% more targets with the Prime filter than all other conditions combined. Two volunteers had difficulty with all of the glasses. Another had trouble with the 250m low contrast target with the green frontserts and the Prime filter. Overall, the Prime filter presented the most problems for the volunteers. These problems were attributed to the shape of goggles in which the Prime filter was mounted. Also this was the only filter condition in which the volunteers were forced to detect, acquire, and engage the targets monocularly. Loss of depth cues, associated with monocular viewing, and restricted field of view, caused by the shape of the goggle holder, also help explain the deleterious effect the Prime filter had on marksmanship performance.

Most of the volunteers who shot well had no comments. One volunteer said he had difficulty seeing the 250m targets with both frontserts and the Prime

filter even though this was not reflected by his performance. Other volunteers also had trouble locating the 250m targets while wearing the frontserts and the Prime filter.

Certain filters increased the acquisition time. This was demonstrated by an increase in No Fires while using the brown frontsert and Prime filter. The lower transmissivity of these filters not only increased the acquisition time, but also prolonged the time to engagement. Most marksmen will not engage a target until they are confident that they have an accurate aim. These filters could prolong the engagement time by decreasing the contrast of the target with respect to the background. In support of this argument, one of the volunteers who had trouble with only the Prime filter was given as much time as he wanted; his performance improved dramatically.

The 100m target had the greatest number of No Fires. (Presentation time was 2 sec compared to 4 sec for the 250m targets.) Thus, the 100m target required immediate engagement. Most volunteers had trouble with this target only while using the brown frontsert or Prime filter. Two volunteers had no trouble with this target under any of the conditions and one volunteer had trouble with this target using both frontserts as well as the Prime filter.

CONCLUSION

This study indicates that marksmanship performance was affected by certain filter conditions, noticeably the brown frontsert and the Prime filter. The data suggest that increased practice and experience with this type of testing can improve an individual's performance. This is shown by better performance under all of the conditions for the volunteers who had participated in previous Weaponeer studies. However, their performance was still affected; most noticeably, the Prime filter. Since the performance decreased as the transmission of the filter decreased, performance could be more markedly affected under lower ambient light levels. Therefore, in a combat situation, performance could be adversely affected by certain laser protective eyewear worn by untrained troops or under marginal viewing conditions. It is necessary to conduct further studies in this area to completely

determine the factors causing the decrease in performance seen with some of the filters, and to determine if increased practice and experience with the protective eyewear can increase performance and partially eliminate the effects of certain filters.

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Appendix 1

Post Hoc Test - 100m Target

	Prime filter	brown front	green front	sun glass	clear B-LPS	control
Prime filter	0	NS	**	**	**	**
brown frontsert		0	NS	**	**	**
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

Post Hoc Test - 250m Low Contrast Target

	Prime filter	brown front	green front	sun glass	clear B-LPS	control
Prime filter	0	NS	**	**	**	**
brown frontsert		0	NS	NS	NS	NS
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

NS - not statistically significant
** - statistically significant

Appendix 1 (continued)

Post Hoc Test - 250m High Contrast Target

	Prime filter	brown front	green front	sun glass	clear B-LPS	control
Prime filter	0	NS	NS	**	**	**
brown frontsert		0	NS	**	**	**
green frontsert			0	**	**	**
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

NS - not statistically significant
** - statistically significant

Appendix 2

Individual Performance* (Number of Hits)

Target 1 - 100m

Sub.	Control	Clear	Sun	Green	Brown	Prototype
1	8	6	6	9	5	5
2	8	10	8	8	8	8
3	7	8	9	10	7	8
4	10	10	9	9	7	8
5	8	8	8	9	8	4
6	10	10	10	10	10	10
7	8	8	9	8	6	7
8	10	9	10	9	7	8
9	7	8	7	2	5	3
10	10	9	10	9	10	8
11	10	10	10	10	10	9

Target 2 - 250m Low Contrast

Sub.	Control	Clear	Sun	Green	Brown	Prototype
1	5	4	3	3	1	1
2	7	9	8	7	6	2
3	4	6	8	5	7	5
4	10	8	9	10	10	9
5	5	5	2	8	3	0
6	9	8	10	6	7	9
7	9	9	6	4	3	6
8	7	7	7	7	3	4
9	6	5	3	0	5	4
10	9	7	8	6	9	5
11	10	10	9	10	9	1

Target 3 - 250m High Contrast

Sub.	Control	Clear	Sun	Green	Brown	Prototype
1	5	5	7	6	7	2
2	7	9	9	6	5	7
3	6	6	8	5	4	4
4	10	9	10	9	7	8
5	5	3	5	2	1	1
6	9	9	9	9	10	7
7	8	7	4	1	4	7
8	9	6	6	5	3	4
9	7	8	2	0	1	3
10	9	10	8	9	7	9
11	10	9	7	8	8	5

* - 10 rounds per condition

Appendix 2 (continued)

Number of Target Hits

Subject No.	Day 1	Day 2	Total
1	47	45	92
2	70	67	137
3	57	62	119
4	80	82	162
5	45	44	89
6	83	79	162
7	63	55	118
8	60	62	122
9	41	46	87
10	78	74	152
11	75	80	155

Appendix 3

Post Hoc Test - 100m Target
(Group 1)

	Prime filter	brown front	green front	sun glass	clear B-LPS	control
Prime filter	0	NS	NS	**	**	**
brown frontsert		0	NS	NS	**	**
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

Post Hoc Test - 250m Low Contrast Target
(Group 1)

	Prime filter	brown front	green front	clear B-LPS	sun glass	control
Prime filter	0	NS	NS	NS	**	**
brown frontsert		0	NS	NS	NS	NS
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

NS - not statistically significant
** - statistically significant

Appendix 3 (continued)

Post Hoc Test - 250m High Contrast Target
(Group 1)

	Prime filter	brown front	green front	sun glass	clear B-LPS	control
Prime filter	0	NS	NS	NS	**	**
brown frontsert		0	NS	NS	**	**
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

NS - not statistically significant
** - statistically significant

Appendix 4

Post Hoc Test - 100m Target
(Group 2)

	Prime filter	brown front	green front	sun glass	control	clear B-LPS
Prime filter	0	NS	NS	**	**	**
brown frontsert		0	NS	NS	NS	NS
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
control					0	NS
clear B-LPS						0

Post Hoc Test - 250m Low Contrast Target
(Group 2)

	Prime filter	brown front	green front	sun glass	clear B-LPS	control
Prime filter	0	NS	NS	NS	**	**
brown frontsert		0	NS	NS	**	**
green frontsert			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

NS - not statistically significant
** - statistically significant

Appendix 4 (continued)

Post Hoc Test - 250m High Contrast Target
(Group 2)

	green front	brown front	Prime filter	sun glass	clear B-LPS	control
green frontsert	0	NS	NS	NS	**	**
brown frontsert		0	NS	NS	**	**
Prime filter			0	NS	NS	NS
sun glasses				0	NS	NS
clear B-LPS					0	NS
control						0

NS - not statistically significant
** - statistically significant

Appendix 5

Individual Performance (Number of No Fires)

Target 1 - 100m

Sub.	Control	Clear	Sun	Green	Brown	Prototype
1	1	2	2	1	3	2
2	0	0	0	1	1	0
3	1	0	0	0	2	2
4	0	0	0	0	0	2
5	2	0	0	0	0	6
6	0	0	0	0	0	0
7	1	0	1	0	2	3
8	0	1	0	1	2	1
9	0	0	3	3	5	6
10	0	1	0	1	0	0
11	0	0	0	0	0	0

Target 2 - 250m Low Contrast

Sub.	Control	Clear	Sun	Green	Brown	Prototype
1	0	0	2	5	1	1
2	0	0	0	0	0	1
3	0	0	0	0	0	0
4	0	0	0	0	0	0
5	0	0	2	2	0	4
6	0	0	0	0	0	0
7	0	0	0	0	2	1
8	1	0	0	0	1	0
9	0	0	0	1	1	0
10	0	0	0	0	0	0
11	0	0	0	0	0	1

Target 3 - 250m High Contrast

Sub.	Control	Clear	Sun	Green	Brown	Prototype
1	1	1	0	0	0	1
2	0	0	0	0	0	0
3	0	0	0	0	0	1
4	0	0	0	0	0	0
5	0	0	0	0	0	1
6	0	0	0	0	0	0
7	1	0	0	0	0	1
8	0	0	0	0	0	0
9	0	0	0	1	0	0
10	0	0	0	0	0	0
11	0	0	0	0	0	1

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